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ABSTRACT

Reported is a study of the effectiveness of the Energy Environment Simulator (EES) in developing energy awareness and positive attitudes towards energy issues in students at various levels of cognitive development. The EES is a portable computer model of U.S. energy resources, environmental quality and food distribution. Subjects were students from university educational psychology classes. Prior to treatment, level of cognitive development was measured by the Test of Logical Thinking (TOLT). The study involved a comparison of two treatments: (1) the EES (N=25); and (2) a lecture-slide presentation covering major ideas normally encountered in the EES program (N=20). Upon completion of the assigned treatments, students completed an Energy Awareness Attitude Assessment (EAAA), an instrument consisting of 20 questions dealing with knowledge of energy concepts and 16 questions measuring attitudes towards energy issues. Analysis of variance revealed that in general the EES was significantly more effective in teaching energy concepts than was the lecture-slide presentation. Individuals at higher developmental levels scored significantly better on the concepts test than did students at lower levels. No significant differences in attitudes were found. Included in the appendix is the EAAA instrument. (Author/WB)

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Developing Conservation Attitudes and Energy Concepts in Individuals of Various Cognitive Levels, Using the Energy Environment Simulator

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Developing Conservation Attitudes and Energy Concepts in Individuals of Various Cognitive Levels, Using the Energy Environment Simulator

Method of instruction should be related to content presented and the capabilities of learners. Students high in a particular aptitude learn better when taught by one method, while students low in that aptitude learn more effectively from another instructional technique (Cronbach & Snow, 1977). One measure of learner aptitude is level of cognitive development as defined by Piaget (Flavell, 1963). If efficacy of method is related to a student's level of development, the developmental range of the target audience should be considered when developing an educational program.

Energy has become an increasingly important topic of education in recent years. Various energy education programs designed to increase public understanding of concepts relating to energy use, and to influence public attitudes toward energy issues, have been developed during the past decade. The oil embargo of 1973, shortages of certain fossil fuels, and general increases in the cost of energy have threatened the way of life in all nations of the world. It has become apparent to various organizations in the public and private sector, that many of the energy decisions made in the past century have been poor ones. If Americans are to make better decisions in the future, they must become more energy literate and develop more realistic attitudes toward energy (McRae & Dudas, 1977).

Energy Environment Simulator

The Energy Environment Simulator (EES) is a portable computer with remote control panels, which allow a group of up to thirty individuals to interact with a computer model of the United States' energy resources in the context of per capita energy consumption. The participants are faced with balancing

the energy consumption of the United States with energy production and distribution while maintaining a quality environment and providing sufficient food for the population.

History

The EES was developed in 1973 for the United States Atomic Energy Commission (Amend, 1980). Eight of the first generation simulators were produced in 1973. During the next seven years a large number of Energy Environment Simulators were produced and widely disseminated.

In 1980 a new generation of EES was produced. This model employed technology of digital computers in conjunction with microprocessors, allowing the simulator to be reprogrammed with data from other countries or geographic regions. A memory mode was added which allows the data generated during a simulation to be recalled for graphing and analysis. The displays were improved and at any moment during the presentation a presenter can display the percentage of energy being drawn from each resource. A lag mode was added to require participants to anticipate energy need in advance. This more accurately represented the time it takes to develop energy resources.

The eight microprocessor EES units produced so far, bring the total number of simulators available in the United States and Canada to well over 100. Research as to the effectiveness of the EES in developing energy awareness and/or changing attitudes toward energy and its use, has been conducted with earlier versions of the simulator.

The EES was designed to increase knowledge and effect attitudes of the adult population. This simulation allows the audience to participate in a problem-solving activity dealing with interactions between energy, environment, population, and food. Levels of thought required of participants in this com-

plex simulation and how well those levels correlate with the individual's level of cognitive development may influence the effectiveness of the simulator program in increasing energy awareness and contributing to attitudinal development.[1]

Research on the Effectiveness of the EES

Dunlop (1979) measured teacher attitude before and after a presentation using the EES. He discovered that scores for 70% of the items on his attitude survey instrument were significantly higher (p=.05) on the post test.

Mercer (1979) measured the effect of the EES on the attitudes and energy awareness of high school students. The test results from the treatment group were compared to those taken from a control group which participated in a slide-lecture presentation. The results for the attitude and awareness sections of the test were not conclusive. The EES was significantly better than the slide-lecture on some items, but significantly poorer on others. No attempt was made to equate the content of the two treatments.

The EES has been used to develop attitudes related to energy and teach knowledge about energy. Studies attempting to measure the effectiveness of the EES have produced conflicting results. No study has been conducted with the new microprocessor version of the EES.

Cognitive Development

Piaget's description of learner characteristics can be helpful in selecting appropriate methods of instruction. According to Lawson (1978) individuals at the concrete level of development learn very little from an abstract verbal presentation of information. Fifty percent of the adult population (post high school) is below the formal level of development (The Educational Policies

Commission, 1961). Over half of high school students are below the formal level of development (Kohlberg & Gilligan, 1971; McKinnon & Renner, 1971). Lawson (1975) explains the need for experience. "In other words it is experiences with materials of the discipline that produce the person who can understand abstract content and not studying the abstract," (p. 338).

Energy is a complex topic involving many interacting issues. It is certain to be one of the major world problems for several years. Improved methods of developing an increased energy awareness and improved attitudes toward wise utilization of energy resources could result in better energy and environmental decisions in the future.

The EES has been used extensively over the past seven years to develop energy awareness and positive attitudes toward wise energy use.

The Problem

The effectiveness of the EES in teaching energy concepts to individuals at varying levels of cognitive development was the focus of this study. If the EES is more effective in developing attitudes and/or energy awareness for individuals at a particular level of cognitive development it can serve as a model for developing energy curriculum in the future.

Energy awareness was used in this study to mean cognitive knowledge relating to issues dealing with conversions, limits, sources, environmental impacts, and uses of energy. Energy attitudes referred to feelings or beliefs concerning right and wrong as related to energy and associated environmental issues.

Methods

This study was designed to measure effectiveness of the EES in developing

energy awareness and positive attitudes toward energy issues in subjects representing various levels of cognitive development. The Energy Awareness Attitude Assessment (EAAA) was developed for use as the dependent variable. A pilot study was conducted to refine the treatments and procedures. Statistical analysis of the pilot study data was used in revising the EAAA.

Subjects

Subjects were recruited from university educational psychology classes during spring semester 1981. Volunteering for this study was an optional means of fulfilling one of the out-of-class projects required for successful completion of the course. Students were informed the study would require about two hours to complete.

Instruments

The instruments utilized in this study include the Test of Logical Thinking (TOLT) to measure level of cognitive development and the EAAA to measure energy awareness and attitudes toward energy issues.

Test of Logical Thinking. TOLT was used to measure subject's level of cognitive development as defined by Piaget (Tobin & Capie, 1980). This ten question paper-pencil instrument was developed as a classroom test for measuring ability of individuals to use formal thought. The TOLT is composed of five pairs of questions. Each pair is designed to measure one of the modes of formal thought described by Lawson (1978). The modes include: correlational reasoning, proportional reasoning, combinational reasoning, probabilistic reasoning, and controlling variables. The TOLT is similar to the Classroom Test of Formal Reasoning (CTFR) (Lawson, 1978). The advantages of the TOLT

over the CTFR include: it takes less equipment to administer; it takes less time to administer; and it includes items for measuring each of the five formal modes. Correlational reasoning, which is not measured by specific items on the CTFR, is measured on the TOLT using items developed by Lawson, Adi and Karplus (1979).

The TOLT employs a multiple-choice format for the first eight items. The last two items require subject to designate all possible combinations of a list of factors. The first eight items require subjects to select correct answers and reasons for their choices from lists of possible answers and reasoning strategies. Lawson required subjects to write out reasons for selecting answers on the CTFR. Correct reasons as well as answers are required for items to be counted correct. Tobin and Capie found it facilitated administration and grading of the TOLT to use a multiple choice format for both the answer and the reasoning strategy. As in Lawson's test, both reason and answer must be correct for items to be considered as indications of the subjects ability to successfully employ a mode of formal thought. This requirement reduces the chance of subjects selecting correct answers by guessing. The range of scores for the TOLT is 0 to 10. TOLT was tested for reliability with coefficient alpha. In a test of 682 subjects, alpha equaled .85. The internal consistency of the two item pairs ranged from .56 to .82 (Tobin & Capie, 1980).

Content validity was supported by the fact all items for the TOLT were taken from other instruments previously reported to be valid measures of formal thought. Criterion-related validity was established by comparing the results of the TOLT with five interview tasks designed by Inhelder and Piaget. Each of the tasks was designed to measure one of the five modes of formal reasoning ability. The corrected coefficient for criterion-related validity was .82.

Factor analysis was also used to support validity of the TOLT (Tobin & Capie, 1980).

Energy Awareness Attitude Assessment. The EAAA is a 36 item paper-pencil instrument consisting of 20 questions dealing with energy awareness and 16 questions measuring attitude toward energy and energy related issues (see appendix A). An awareness score and an attitude score are calculated from the EAAA. Attitude and awareness items are randomly distributed throughout the instrument. Awareness items are multiple-choice with only one correct answer for each question. Correct responses are reported as 1 and incorrect responses as 0. Scores for individual items are summed providing a possible range of scores extending from 0 to 20.

Attitude items consist of statements to which subjects are asked to respond by selecting one of four choices on a Likert-type scale. Possible responses included: "Strongly Agree," "Moderately Agree," "Moderately Disagree," and "Strongly Disagree." "Strongly Disagree" is considered the most desirable response for ten items, while "Strongly Disagree" is considered most desirable for the remaining six items. Scoring of the attitude portion of EAAA is accomplished by assigning from 1 to 4 points to each of the 16 responses. Four points are assigned to each item where the most desirable choice is selected; 3 points if second most desirable is selected; 2 points if the third most desirable is selected; and 1 point if the least desirable is selected. Scores from individual attitude items are summed providing a possible range of from 16 to 64. Correct answers for the attitude section were determined by selecting those responses indicating attitudes fostered by presentations of the EES. The developer of the EES model was consulted to verify these answers (Amend, 1981).

A presentation of the EES was recorded and the proceedings transcribed to determine the content of the presentation. A list of facts, concepts, and generalizations concerning energy and energy-related issues was composed. These were used as a basis for selecting and composing items for the EAAA.

Twenty-three items for EAAA were adapted, or taken directly from Energy Knowledge and Attitudes, a national survey of young adults developed and conducted by the National Assessment of Educational Progress (1978). This instrument contains 70 knowledge questions and 76 items dealing with attitude or opinion. The survey involved 1300 adults ranging from 26 to 35 years of age. A multiple choice format is employed with the knowledge questions and a Likert-type scale is used for attitude items. Seven items for the EAAA were adapted from materials developed by the Wichita School District Energy Adventure Center (Daley, 1979). Six items were written specifically for the EAAA, These items along with the items from other instruments were included in the early drafts of EAAA. Items were revised or eliminated as a result of testing in the pilot study.

Content validity for the 30 items adapted from other tests was supported by the demonstrated validity of the parent instruments. Validity of the complete EAAA was supported by 15 judges familiar with the EES and with extensive experience in energy education.

Reliability for the EAAA was established independently for awareness and attitude sections of the instrument. Data were analyzed using Spearman-Brown unequal length split-half procedure (Nie, Hull, Jenkins, Steinbrenner, & Brent, 1975). The first draft of EAAA was administered to a university elementary school science methods class. Results were analyzed and individual items were

rewritten or discarded on the basis of content, difficulty, inter-item correlation, and predicted alpha if the item were deleted. New items were added to replace deleted items and cover topics from the presentation not measured in the initial draft. The revised EAAA was administered as part of the pilot study. A second revision was conducted using the same criteria employed to edit the first draft. The final draft of EAAA was checked for improvement by administering the instrument to 46 junior high school students representing a social studies class and a gifted and talented program. The reliability coefficient was .72 for awareness and .71 for attitude. EAAA was also administered to 17 high school physics and electronics students resulting in reliability coefficients of .58 for awareness and .85 for attitude. Reliability coefficients for the instrument when administered to the 60 subjects in this study were .67 for awareness and .67 for attitude.

Treatments

This study was designed with two treatments. Lecture and simulation treatments were conducted separately. Lecture treatment consisted of a presentation of The Epoch of Fossil Fuels (Kirkpatrick, 1979). With slight modification, this slide-lecture presentation covered all major ideas normally presented in the EES program. The lecture presentation required 47 minutes and the simulator presentation required 78 minutes. Not all of the time in the simulator session involved presentation of material, approximately half of the time students were taking part in the simulation.

The lecture presentation provided numerous examples of calculations illustrating the concepts and generalizations described, as well as pictures and graphs. Both simulator and lecture presentations have been used in energy

presentations for high school, university, and citizen groups.

Presenters were selected on the basis of similarity in age, educational background, presentation skills and lack of previous experience in making energy presentations. Neither was aware of the content of EAAA.

Upon completion of their assigned treatment, subjects were asked to complete the EAAA. Data from tests of subjects having prior experience with the EES were discarded.

Prior to taking part in the treatments, subjects were tested to determine their level of cognitive development. TOLT was administered as a part of the regular course work. Subjects were not informed there was any connection between the TOLT and the study. Different individuals administered TOLT, recruited volunteers, and conducted the treatments.

A stratified random procedure was used in an attempt to equally distribute individuals having the same TOLT scores between the experimental treatments. The simulation group consisted of 25 subjects and the lecture group consisted of 20 subjects. The unequal number of subjects in treatment groups was due to the number of individuals having the same TOLT score not being evenly divisable by two, volunteers failing to show up for a treatment, and discarding data due to subject's prior experience with the EES.

Analysis of Data

Data were analyzed using a regression program. The regression model was used in an analysis of variance as described by Kerlinger and Pedhazur (1973).

Independent variables included lecture and simulation as categorical variables and TOLT as a continuous variable. The dependent variable, EAAA, was divided into awareness and attitude sections. Each section was analyzed

as a separate measure. Dummy coding was used to represent treatment variables. The interaction between the main effects (treatment X TOLT) was computed and tested for significance.

The linear regression model tested was:

$$Y = A + B_1X_1 + B_2X_2 + B_3X_1X_2$$

where,

Y = value of the dependent variable (awareness, attitude),
A = Y intercept,
B_1 = regression coefficient of treatment,
X_1 = code for treatment (0 = lecture 1 - simulation),
B_2 = regression coefficient of TOLT,
X_2 = TOLT score, and
B_3 = regression coefficient of interaction.

Analysis was conducted twice, once for awareness and once for attitude. Significance was determined by the F ratio of variance attributed to each regression coefficient (after shared variance had been subtracted) divided by error mean square. The $p=.05$ level of significance was used to test all main effects and interactions.

The Johnson-Neyman technique was used to determine region of significance for regression lines that represent significant interactions (Kerlinger & Pedhazur, 1975).

Results

Awareness

Results of the analysis using the awareness score from the EAAA as a dependent variable are summarized in Table 1.

Table 1

Analysis of Variance Summary Table

Independent Variables: Cognitive Level, Treatment

Dependent Variable: Awareness

Source	Mean Square	Degree of Freedom	F	Level of Significance p
Treatment	.19973	1	13.58	<.01
Cognitive Level	.17417	1	11.84	<.01
Interaction (treat. X Cog. Level)	.07661	1	5.21	<.05
Error	.01471	41		

The mean awareness score for the simulation group was 13.84 The mean score for lecture was 11.40. This significant difference indicates the EES was more effective in teaching energy awareness information than the slide lecture presentation. Individuals at higher levels of cognitive development scored significantly better on the awareness test than individuals at lower levels of cognitive development.

The significant interaction of cognitive level and treatment is represented by the difference in slope of the regression lines for lecture and simulation (see figure 1). The interaction was ordinal since the lines do not cross within the range of TOLT scores. This interaction indicates individuals at different cognitive levels respond in varying degrees to the treatments. The difference in scores for the treatment groups was much greater for individuals of lower cognitive levels than for individuals of higher cognitive levels. Johnson-Neyman technique was used to determine at what point (TOLT score) the regression lines were significantly different.

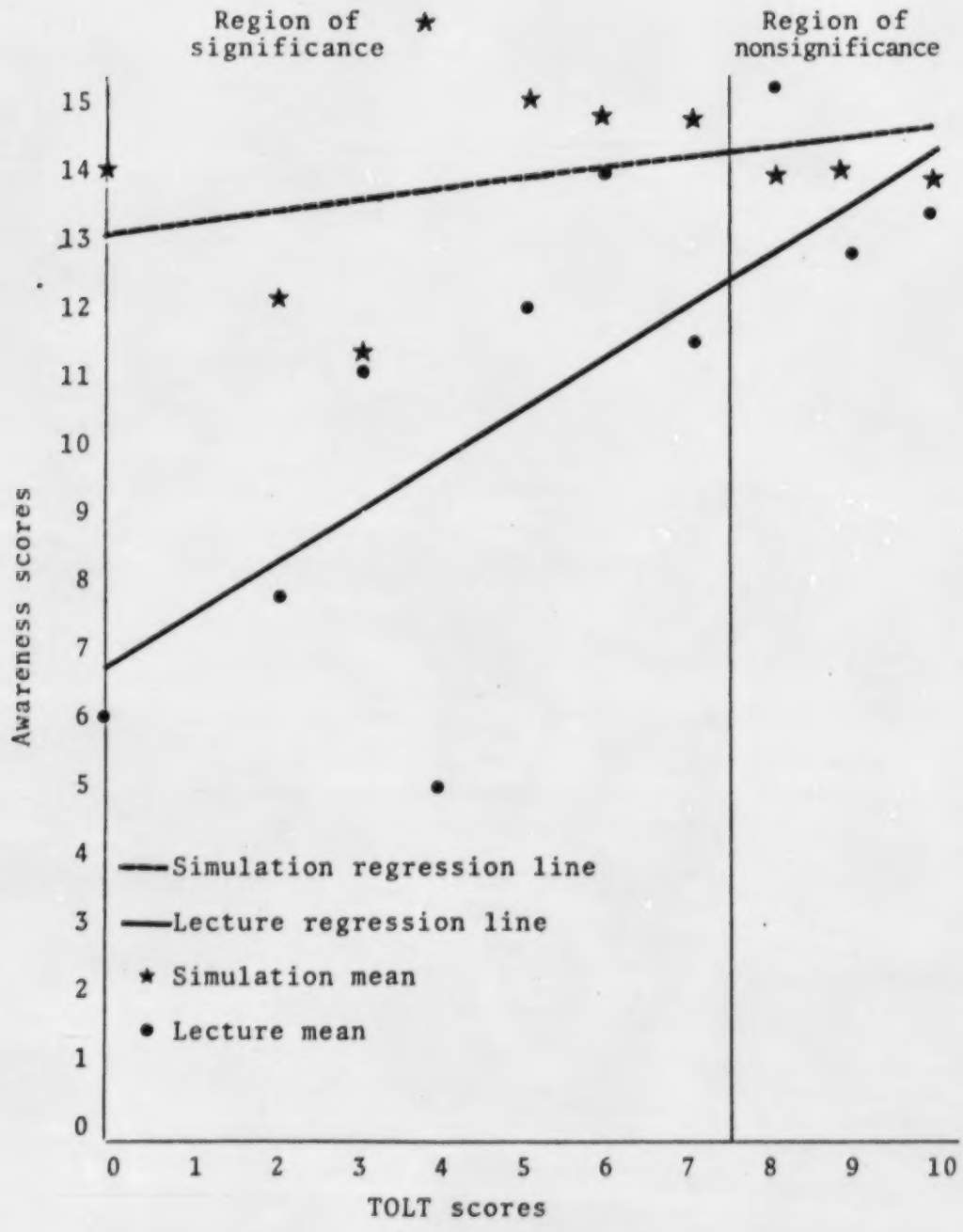

Figure 1.--Regression lines for simulation and lecture treatments plotted with awareness score means for individual TOLT scores

The region of significance is below 7.47 on the scale of TOLT scores. This indicates there is no significant difference in awareness scores that can be attributed to treatment for individuals with TOLT scores of 8 or higher.

Attitude

Results of the analysis using the attitude score from the EAAA as a dependent variable are summarized in Table 2.

Table 2
Analysis of Variance Summary Table
Independent Variables: Cognitive Development, Treatment
Dependent Variable: Attitude

Source	Mean Square	Degree of Freedom	F	Level of Significance p
Treatment	.00198	1	.0825	>.05
Cognitive Level	.00183	1	.0763	>.05
Interaction (treat. X Cog. Level)	.0105	1	.4388	>.05
Error	.0240	41		

There were no significant differences in the attitude scores that can be attributed to the treatment group or level of cognitive development. Examination of the data reveals no significant interaction between treatment and cognitive level for attitude.

It is difficult to compare studies dealing with attitudes, but most successful attempts to change attitude seem to involve repeated treatments or treatments of longer duration (Collins, Herbkersman, Phelps, and Barrett, 1978;

Wager, 1979; Wilson and Tomera, 1980).

Summary

The Energy Environment Simulation was more effective than a slide-lecture presentation in teaching energy awareness information to individuals at the formal and pre-formal levels of cognitive development. The EES allows individuals of lower cognitive levels to learn almost as much as their more cognitively mature peers. The EES was not shown to be effective in changing attitude within the limitations of 78 minute presentation. Level of cognitive development appears to be an important criterion for determining the most effective instructional strategy to be used with individuals. It seems that lecture is effective for instruction of individuals at the formal level of development, but individuals that are not clearly formal require more concrete activities.

Reference Notes

1. The microprocessor simulators are marketed by Energy and Man's Environment, 7478 Southwest Nimbus Avenue, Beaverton, Oregon 97005.

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APPENDIX A

ENERGY AWARENESS AND ATTITUDE ASSESSMENT

Name _____

ENERGY AWARENESS ATTITUDE ASSESSMENT

INSTRUCTIONS: Select the best answer for each question and write the appropriate letter in the blank to the left of the number.

___ 1. In the long run, which is the largest potential source of energy?

A. Coal
B. Plutonium
C. Petroleum
D. Uranium
E. Sun
F. I don't know

___ 2. Improved technology will eventually make it possible to convert to useful work all of the energy released by burning a fuel.

A. True B. False C. I don't know

___ 3. The energy problems in the United States are past.

A. Strongly Agree
B. Moderately Agree
C. Moderately Disagree
D. Strongly Disagree

___ 4. Which one of the following now uses the largest share of the United States' energy supply?

A. Homes
B. Transportation
C. Commercial buildings (schools, stores, etc.)
D. Industry
E. I don't know

___ 5. Energy problems in the United States will all be solved in ten years.

A. Strongly Agree
B. Moderately Agree
C. Moderately Disagree
D. Strongly Disagree

___ 6. Some people think that the solution to coal, gas, and oil shortages is to switch over to electricity. In other words, if we run out of gas and oil we can just switch over the electric cars. What is wrong with this idea?

A. Most electricity is produced from coal, gas, and oil.
B. If we switch over to electricity may people will lose their jobs.

_____7. Energy shortages pose a serious threat to the future well-being of most Americans.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

_____8. Approximately what percentage of the oil consumed by the United States is imported from foreign countries?

A. 15% - 25% B. 25% - 35% C. 35% - 45% D. 45% - 55% E. I don't know

_____9. The United States and other "have" nations are consuming more than their fair share of energy resources.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____10. The United States has approximately 6% of the world's people. About what percentage of the total amount of energy consumed on the earth in a year does the United States consume?

A. 6% B. 15% C. 30% D. 70% E. I don't know

____11. In 1973, the United States used 6.3 billion barrels of oil. If we continue using this much oil each year, about how many years of oil supply do we still have in the United States?

A. 10-50 years B. 50-100 years C. 100-150 years
D. 150-300 years E. I don't know

____12. We should make substantial investments in research and development of new energy sources (solar, wind, etc.).

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____13. Which one of the following does not use a fossil fuel as a raw material?

A. Glass B. Plastic C. Nylon D. Ammonia fertilizer
E. Asphalt F. I don't know

____14. Establishing maximum winter thermostat settings for public buildings was a good thing.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____15. Which one of the following requires the least energy to move freight?

A. Truck B. Train C. Airplane D. Helicopter E. I don't know

____16. The general public needs more information on how they can save energy.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____17. Topics like basic energy knowledge, energy problems, the future of energy, etc. should definitely be an important part of every school's curriculum.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____18. Which one of the following sources now provides the largest percentage of energy used in the United States?

A. Crude oil B. Natural gas C. Water (hydroelectric) power

D. Nuclear energy E. I don't know

____19. There will not be any gasoline shortage in the United States again.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____20. The largest fossil fuel energy reserves in the United States are reserves of which one of the following?

A. Natural gas B. Crude oil C. Coal D. Tar Sand E. I don't know

____21. The consumer is largely responsible for the severity of our energy problems.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____22. Which of the following is/are presently used as a means of generating power for useful purposes?

A. Only Fusion B. Only Fission C. Both D. Neither E. I don't know

____23. Americans should develop energy independence even if it means that energy will cost more.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____24. How much time is required to get a coal fired power plant into production?

A. About 6 months B. About 1 year C. About 2 years D. About 8 years E. About 15 years F. I don't know

____25. Which energy source are we likely to run out of first?

A. Coal B. Natural gas C. Petroleum D. Sun E. I don't know

____26. Which energy source involves "breeders"?

A. Coal B. Nuclear C. Petroleum D. Natural gas E. Sun F. I don't know

____27. Which one of the following pollutants is produced by fossil fuels and nuclear power plants?

A. Waste heat B. Fly ash C. Unburned hydrocarbons
D. Sulfur compound E. I don't know

____28. The original energy source for most of the electrical energy produced in the United States is -

A. Falling Water B. Nuclear energy C. Coal D. Oil
E. Natural gas F. I don't know

____29. If the government would deregulate the price of oil and natural gas we would be able to develop as much of those resources as we are currently using for the next several hundred years.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____30. Individuals have the responsibility to analyze their use of energy and to waste less.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____31. Which of the following are considered renewable sources of energy?

A. Petrolium and Natural Gas B. Coal C. Nuclear D. Wind and Falling water

____32. Most of the concern about energy problems has been exaggerated.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____33. Which of these uses the most energy in the home?

A. Heating B. Television C. Lights D. Radio

____34. Even though it might be inconvenient and require special effort, I would be willing to work toward demanding improved efficiency in energy production and use.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

____35. In 1984, the principal United States supplier of energy will <u>most likely</u> be:

A. Fossil fuel B. Solar space stations C. Nuclear reactors

D. Geothermal

____36. If the search for new energy sources will cost me more money, then I would want the search stopped.

A. Strongly Agree B. Agree Moderately C. Disagree Moderately D. Strongly Disagree

ENERGY AWARENESS AND ATTITUDE ASSESSMENT - KEY

1)	E	19)	D
2)	B	20)	C
3)	D	21)	A
4)	D	22)	B
5)	D	23)	A
6)	A	24)	D
7)	A	25)	B
8)	D	26)	B
9)	A	27)	A
10)	C	28)	C
11)	B	29)	D
12)	A	30)	A
13)	A	31)	D
14)	A	32)	D
15)	B	33)	A
16)	A	34)	A
17)	A	35)	A
18)	A	36)	D